A NOVEL LASER BRUTING MACHINE.

Technical Field

The present invention relates to A Novel Laser Bruting Machine.

The diamond has always exercised an irresistible seductive power and acquired an almost mythical fame because it is the most expensive of gems and the hardest of all minerals. Each diamond stone must therefore be studied in detail in order to determine the most advantageous manner to work it with the least loss of weight. In its unpolished form, a diamond is a rather vague crystal form, without any real luster. Only a succession of process such as marking, cleaving, sawing, girdling, etc. gives it its final facet form and brilliance. Girdling is the rounding of the base of sawn (or cleaved) piece so that it has more or less the form of a polished diamond. In conventional machine to achieve girdling of rough diamond stone, the sawn diamond is mounted on the chuck of a lathe and the desired rounded form is achieved by turning it against another diamond, as the cutting tool. The excess surface of the rough diamond cut with the conventional machine is imprecise. The conventional bruting machine works with lower speed and has the high weight loss. This is due to the cutting force spreads to other parts of the diamond. As each diamond is unique it has become imperative to develop new techniques in order to improve the productivity of the diamond industry.

Background Art

A novel laser bruting machine is invented to overcome above limitations experienced by conventional bruting machine. With a novel laser bruting machine, bruting becomes a non-contact very fast process compared to conventional bruting machine. As laser bruting being a non-contact process gives more speed, reduces weight loss significantly and keeps the shape of diamond uniform. In novel laser bruting machine the computer becomes an important element in cu98tting of diamond. With the standard software computer suggest an optimal cut to have accurate rounded shape of the diamond taking dimensions & shape into account. Also the rough diamond stone to be

centered and bruted is lit up by illuminating sources and these illuminating sources consist of plurality of LED's so the eye gets the impression that is always the same side of the stone that is lit and hence the illuminated rough diamond can be watched on CCTV through video system consist of CCD cameras. This is a useful technique, because novel bruting machine can check the process at all times without stopping the machine. Summing up all the advantages productivity increases considerably with a novel laser bruting machine.

Disclosure of the Invention:

The present invention will be described with greater specific and clarity with reference to following drawings:

Fig. 1 represents front view of bruting machine.

Fig. 2 represents diamond holder.

Fig. 3 represents top view of rough diamond with possible maximum diameter

Fig. 4 represents front view of setup device.

Fig. 5 represents side view of setup device.

Fig. 6 represents top view of setup device.

Fig. 7 represents front view of bruting processing system.

Fig. 8 represents front view of girdle polishing system.

Fig. 9 represents block diagram of Beam delivery mechanism.

Fig. 10 represents trolley containing power supply and heat exchanger.

Fig. 11 represents block diagram of cooling system & chilling system of heat exchanger.

Fig. 12 represents front view of chilling water tank.

Fig. 13 represents front view of split tank.

Fig. 14 represents diamond

Fig. 15 represents flow chart.

Fig. 16 a represents random/initial position of rough diamond stone.

Fig. 16 b represents position of center of rough diamond stone on X-axis.

Fig. 16 c represents position of rough diamond stone when it is centered.

A Novel Laser Bruting Machine consist of (i) diamond holder **8** (ii) Setup device **3**, & (iii) processing device **4**; diamond holder **8** consist of stitching die **6**, magnetic die **7** and rough diamond **5**; setup device **3** consist of CNC interface, video system; Processing device **4** consists of CNC interface, heat exchanger **25**, video system, beam delivery mechanism **26**, laser source **27**, RF-Q Switch driver **28**, power supply **29** & stabilizer.

Bruting machine **1** which is accommodated on aluminum frame **2** consists of mainly three sections.

(1) Diamond Holder **8**

(2) Set up device **3**

(3) Processing device **4**

(1) Diamond Holder 8: A rough diamond **5** to be processed for Bruting or Girdle Polishing is stitched on top of the stitching die **6** by adhesive & heat. Due to magnetism of magnetic die **7**, stitching die **6** is fixed on top of magnetic die **7**. Combination of stitching die **6** and magnetic die **7** is referred to as Diamond holder **8**.

An automated gemstone/rough diamond stone **5** centering and data management system is provided to setup device **3**. The physical data of a rough diamond stone/gemstone **5** is determined relative to the measured spectral response of light energy incident to a gemstone **5**. Gemstone **5** is illuminated by a plurality of light sources such that the spectral response of the gemstone **5** is captured as a pixel data set, gauged, quantified and recorded for future reference via CCD cameras. A setup device **3** provides a imaging station for the automated centering and quantifying physical data of gemstone **5**. The video system/ imaging station is linked to computer/analysis station for

communicating captured incident light data sets thereto. The analysis station/computer 16 employs a data processor and model database for assessing the physical data of the gemstone 5 by way of the communicated pixel data sets. The spectral response of a gemstone 5 to the incident light sources is quantified relative to model pixel data sets of the database and recorded for future reference therein. The operation of the setup device 3 is controlled by a control card and instruction set.

The data processor/control card of the analysis station/computer 16 provides an instruction set for facilitating communication with the setup device 3, analyzing communicated pixel sets. The instruction set includes analytical and statistical image models, which extract pertinent physical data of gemstone from the pixel data sets. Additionally, the analysis station includes mass storage memory devices for storing the reference value database; analysis instruction set, and report information, which may include text as well as visual data. The physical data of gemstone 5 are ~~communicated from the setup device 3 to the computer 21 of~~ processing device 4 by means of LAN.

The control data processor/control card of the setup device 3 & processing device 4 provides an instruction set for ~~automating the steps necessary to precisely~~ position and operate the imaging hardware. The imaging system/video system of set up device 3 & processing device 4 extract consistently and accurately, size, shape, and proportion information from the images of a gemstone 5 using the data processing instruction set.

(2) Setup device 3 consist of CNC Interface & Video System

(I) CNC INTERFACE: CNC Interface of setup device 3 comprising of Motorized X axis positioner 9, Motorized rotatable platform 11, Motorized up/down positioner 12, Drive cards 13,14,15, Control card , Computer 16 & Stepper Motors.

(II)Video System of setup device 3 consists of Upper CCD Camera 17 & Lower CCD camera 18.

For accurate girdling/rounding or to remove surrounding excess surface of rough diamond 5 it is essential that rough diamond 5 should have rotating/circular motion around its center point for which it is required that rough diamond 5 along with stitching die 6 should be placed on center of top of the magnetic die 7 and it is done by CNC Interface, Computer 16 with standard software and Monitor 19.

Example:

Because of the Video system, rough diamond 5 appears on the monitor 19. As upper CCD camera 17 & Lower CCD camera 18 are being used, one has option for watching rough diamond 5 either in elevation or plan view. Supposing surface of the rough diamond 5 is being selected by 3-point method considering top view/plan view of rough diamond 5. Then by mouse clicking three random end points of rough diamond 5 are selected and with standard software it gives physical data of rough diamond 5 and also puts stitching die 6 on center of top of the magnetic die 7 automatically using pusher rod 10 of motorized X axis positioner 9 & motorized rotatable platform 11. The physical data of rough diamond 5 & predicted finished diamond 20 can be accessed in processing device 4 as computers 16 & 21 of setup device 3 and processing device 4 respectively are connected with LAN.

Functioning of CNC Interface of setup device 3 :

Example:

Referring to **figure 16a**, assume that center of rough diamond 5 is P(x,y) and thus it is offset from O(0,0). It represents initial position of rough diamond 5 placed on motorized rotatable platform 11 vertically.

Referring to **fig. 16b**, computerized vision system will measure the angle to rotate and by rotary motion, center P of rough diamond 5 is brought on X axis through motorized rotatable platform 11. Stepper motor drives the motorized rotatable platform 11 and hence diamond holder 8 which is placed on motorized rotatable platform 11 also rotates and takes the position on X-axis.

Referring to fig16c, to match the center P with O, Pusher rod 10 which is fixed with Motorized X axis positioner 9 pushes P towards O and hence stitching die 6 is placed on center of top of magnetic die 7. Motorized X axis positioner 9 is driven by stepper motor.

If elevation view or plan view of rough diamond 5 do not appear clearly on monitor 19 then Motorized up/down positioner **12** comes into action to give clear image of rough diamond **5** on monitor **19** by moving vertically. Motorized Up/down positioner **12** is driven by stepper motor.

Drive cards **13,14 & 15** are connected to motorized X- axis positioner **9**, motorized up/down positioner **12** & motorized rotatable platform **11** respectively. Drive cards **13,14,15** are also connected with computer **16**. Drive cards **13,14,15** amplify the electronic signal coming from computer **16** and provides amplified electronic signal to Motorized X axis positioner **9**, Motorized up/down positioner **12**, & Motorized rotatable platform **11**. A contol card which is placed in the computer **16** controls the movement of motorized X axis positioner **9**, Motorized up/down positioner ~~12 & Motorized rotatable platform 11. Also limit switches~~ are provided to each end of motorized X axis positioner **9**, motorized rotatable platform **11** & motorized up/down positioner **12** to sense the home & end position. To switch on or off the drive cards **13,14,15**, drive card power supply **22** is connected to drive cards ~~13,14,15~~.

(3) Processing device 4:

Diamond holder **8** is carried to processing device **4** following the process of centering the stitching die **6** on magnetic die **7**. Diamond holder **8** is fixed horizontally on motorized rotatable platform **23**. As computer **16** of setup device **3** and computer **21** of processing device **4** are connected via LAN and hence physical data of rough diamond **5** taken from setup device **3** is accessed on monitor **24** through standard software installed in computer **21** of processing device **4**.

Mechanism of processing device 4:

Processing device **4** consist of CNC Interface, Heat Exchanger **25**, Video system, Beam delivery mechanism **26**, Laser source **27**, RF-Q Switch driver **28** & Power supply **29**.

(I) CNC Interface of processing device **4** consist of Motorized Y-axis positioner **30** ,Motorized rotatable platform **s**, Motorized X axis positioner **31**, Computer **21**, Monitor **24**, CCTV **32**, Drive cards **33,34,35**, drive card power supply **36** & stepper motors to drive Motorized Y-axis positioner **30**, Motorized rotatable platform **23** & Motorized X axis positioner **31**.

(II) Heat Exchanger 25 consist of Cooling system **37**, Chilling system **38** ,Interlock system **39**. Cooling system **37** associated with de-ionized water circulation from cooling system **37** to Laser head **43** & Q-switch **42** and vice versa. Chilling system **38** associated with water circulation from Heat exchanger **25** to chilling pump system **48** and vice versa. Chilling pump system **48** consist of chilling water tank **70** & split tank **71**. Heat exchanger **25** is connected to Power supply **29** via interlock cable. Interlock system **39** saves machine from getting damaged by switching off the power supply **29** automatically if (i) flow and/or (ii) level and/or (iii) temperature of de-ionized water unnecessarily decreases or increases. Interlock system **39** of heat exchanger **25** comprising of flow LED **49**, Level LED **50** & Temperature LED **51**.

(III) Video system: Video system of processing device **4** comprising of upper CCD Camera **52** and lower CCD camera **53**.

(IV) Beam delivery mechanism 26 of processing device **4** consists of (i) Bruting process system **54** and (ii) Girdle polishing system **55**. Bruting process system **54** consists of (a) sliding beam bender **56** (b) lower beam bender **57** & (c) lower focusing device **58**. Girdle Polishing system **55** consist of (a) upper beam bender **59** (b) upper focusing device **60**. Sliding beam bender **56**, lower beam bender **57** and upper beam bender **59** are placed at 45° with respect to incoming laser beam.Lower focusing device **58** and upper focusing device **60** have illuminating source to illuminate rough diamond **5**. Each illuminating source has plurality of LED's.

(V) Laser Source 27 consist of back mirror **40**, Apertures **41,41,** Q-switch **42**, Laser head **43**, shutter s, polariser **45**, front mirror **46** & beam expander **47**.

Laser head **43** is the crucial part to generate the laser light. Front mirror **46** and back mirror **40**

amplifies the laser light by providing feedback. Q-switch 42 is used to store the laser light energy to emit as a burst of high peak power. Safety shutter 44 blocks the laser beam in case of electrical failure. Safety shutter terminates laser by blocking the laser beam path and preventing emission of laser radiation out of the laser source. The safety shutter 44 is actuated by toggle switch. Apertures 41,41 restrict the light amplification along the off-axis of the resonator to provide sharp frequency band. Beam expander 47 expands the laser beam to minimize its divergence. To polarize laser beam polarizer 45 is used.

(VI) RF-Q Switch driver 28: To get the pulsed laser output with high peak power, the laser is operated in Q-Switch mode. The transducer in acoustic-optic Q-switch 42 requires RF power for operation of Q-switch 42 and such requirement is fulfilled by RF-Q Switch driver 28. The RF source is pulsed at frequencies from 0.1KHz to 50KHz corresponding to the desired pulse repetition rate of the laser. The quartz cell being switched with such a high frequency needs cooling. Therefore the Q-switch 42 also becomes cool. To operate Q-Switch 42 in pulsed mode, RF-Q Switch driver 28 is connected to Q-Switch 42 and computer 21. Computer 21 sends the frequency data to RF-Q switch driver 28 and accordingly laser in laser source is operated in Q-switch mode. As Q-switch 42 is being switched with such a high frequency, it is cooled by circulation of de-ionized water for repetitive operations and therefore interlock system is provided.

(VII) Power supply 29: It ignites and controls the intensity of the laser light emitted by the laser lamp (Kr/Xe arc lamp). The intensity of light produced by the lamp is used for pumping the Nd atoms in Nd:YAG rod. Once the discharge in the lamp is produced, then by changing the current flowing through the lamp, the intensity of light emitted by the lamp can be controlled. In many applications laser is not used continuously and therefore the power supply 29 is provided with a special feature of standby mode which keep alive the discharge in the lamp by producing the optimum current required for the lamp to maintain the discharge in lamp. This particular arrangement is very useful in increasing the operational life of the lamp and also that of power

supply. Because this will save the whole process of generating the trigger pulse for igniting the lamp.

Functioning of Processing Device 4:

A diamond holder 8 which consist of stitching die 6 and magnetic die 7 is carried from setup device 3 and fixed horizontally to motorized rotatable platform 23. In bruting process laser beam coming from laser source 27 falls on sliding beam bender 56 from which it falls on lower beam bender 57 and hence laser beam coming from lower beam bender 57 which is then focused by lower focusing device 58 and finally the focused laser beam falls on gemstone/rough diamond stone 5. And therefore maximum diameter 61 of rough diamond stone/ gemstone 5 is achieved by removing excess surface from it by rotary motion and displacement on particular axis.

Also maximum diameter 61 of rough diamond 5 is achieved with the girdle polishing process. In girdle polishing process laser beam coming from laser source 27 falls on upper beam bender 59 bypassing sliding beam bender 56. A laser beam coming from upper beam bender 59, which is then focused by upper focusing device 60 and hence focused laser beam falls on rough diamond stone 5.

Application of Bruting process 54 or Girdle polishing process 55 is to obtain maximum diameter 61 from rough diamond 5 by removing excess surrounding surface from rough diamond 5. After Bruting process 54 or Girdle polishing process 55 the shape of rough diamond 5 is converted into cylindrical shape in general. To remove excess surrounding surface of rough diamond 5 laser beam from laser source 27 is used.

Procedure for Switching on Heat exchanger 25 & Power supply 29:

Pump on/off knob 62 is accommodated in Heat exchanger 25, which is kept "on" initially and Pump LED 63 is operated by Pump on/off knob 62. Also digital temperature controlling unit 72 & Inter lock system 39 are provided to heat exchanger 25. Then in Power supply 29, T.P. 64 and Lamp 65 switches are switched "on" to trigger laser lamp of laser source 27. Also as power supply 29 is connected with heat exchanger 25 via interlock cable and therefore interlock LED 66 is

provided on power supply 29. Push button switch "Push for control" 67 is pressed to start current setting unit 68. The value displayed in current setting unit 68 can be varied by current variable knob 69. Current setting unit 68 is provided to have desired watt for cutting the surrounding excess surfaces of rough diamond 5. Heat exchanger 25 & Power supply 29 are accommodated in trolley 99.

Example:

The required heat in form of laser beam to cut the surrounding excess surface of the rough diamond 5 depends on the diamond quality. Supposing for a rough diamond 5 the required watt to cut the surrounding excess surface is 25 watt and to have such value current variable knob 69 of power supply 29 is allowed to move until 25 watt is achieved in watt meter.

Application & functioning of Heat exchanger 25:

A large quantity of heat is generated inside the pumping cavity of laser source 27 when laser is produced. If the heat is not removed from the pumping cavity of laser source 27 then it will cause lamp and rod to get damaged and therefore a proper arrangement of heat distribution in terms of heat exchanger 25 is provided to processing device 4. The heat from De-ionized water is subsequently removed by chilling system 38. The temperature of De-ionized water is regulated by means of solenoid, which turns outside water flow from chilling system 38 on and off as required.

Heat exchanger 25 consist of (i) Cooling system 37 (ii) Chilling system 38 and (iii) Interlock system 39. Cooling system 37 circulates de-ionized water from Heat exchanger 25 to Laser head 43 & Q-Switch 42 and vice versa. Also chilling system 38 circulates water from heat exchanger 25 to chilling pump system s and vice versa.

In heat exchanger 25 water circulation from chilling pump system 48 decreases the temperature of incoming de-ionized water at significant level and provides de-ionized water having less temperature to laser head 43 and Q-switch 42. Flow of water from chilling system 38 used for decreasing temperature of incoming de-ionized water from cooling system 37 is getting heated and

hence temperature of such water increases. The temperature of such water is required to decrease by means of chilling pump system **48**. Chilling pump system **48** consists of split tank **71** and chilling water tank **70**.

Example:

Supposing display of digital temperature controlling unit **72** of Heat Exchanger **25** shows temperature of de-ionized water as 35°c. Now if it is required that temperature of de-ionized water should be 30°c then press SET switch of digital temperature controlling unit **72** for few seconds. When present temperature of de-ionized water (35°c) blinks then press up/down push button switches until required temperature 30°c displayed on the display of digital temperature controlling unit **72**. Press the SET push button switch of digital temperature controlling unit **72** when 30°c displayed on display of digital temperature controlling unit **72**. After few moments as temperature of de-ionized water is set at 30°c the chilling pump system **48** of Heat exchanger **25** which decreases the temperature of incoming de-ionized water stops working. Though functioning of chilling pump system **48** remains continue.

Functioning of Chilling pump system 48 of heat exchanger 25:

Digital temperature control unit **73** is provided to chilling water tank **70**. When in display of digital temperature control unit **73** if value of present water temperature is significantly higher than the value of set water temperature then split tank **71** starts working and if value of present water temperature remains around the value of set water temperature then split tank **71** stops working. In this way the Chilling pump system **48** saves the power substantially.

Hence with the Heat exchanger **25**, temperature can be maintained and the same saves the machine from getting overheated.

IN port **74** of Heat exchanger **25** is connected to one end of Teflon connector **75** via hose pipe **82** while other two ends of Teflon connector **75** are connected to OUT port **76** of laser head **43** and OUT port 77 of Q-switch **42** via hose pipes **83,84** respectively. OUT port **78** of Heat exchanger **25**

is connected to one end of Teflon connector 79 via hose pipe 85 while other two ends of Teflon connector 79 are connected to IN port 80 of laser head 43 and IN port 81 of Q-switch 42 via hose pipes 86,87 respectively. OUT port 78 of Heat exchanger 25 provides de-ionized water to Laser head 43 and Q-Switch 42 through IN port 80 and IN port 81 respectively while due to laser heat warm de-ionized water come out from OUT port 76 and OUT port 77 of Laser head 43 and Q-switch 42 respectively and enters into Heat exchanger 25 through IN Port 74.

Chilling OUT port 88 of Heat exchanger 25 is connected to IN port 89 of chilling water tank 70 via hose pipe 95 and OUT port 90 of Chilling water tank 70 is connected to IN port 91 of Split tank 71 via hosepipe 96. OUT port 92 of split tank 71 is connected to dual port 93 of chilling water tank 70 via hose pipe 97 and other end of dual port 93 of chilling water tank 70 is connected to Chilling IN port 94 of Heat exchanger 25 via hose pipe 98.

Water used to decrease the temperature of de-ionized water becomes warm and comes out from chilling OUT port 88 of Heat exchanger 25 and travels towards IN port 89 of Chilling water tank 70. Then this warm water travels into split tank 71 and split tank 71 decreases temperature of warm water and provides such water to chilling water tank 70 and from chilling water tank s water travels into Heat exchanger b through IN port 94.

Functioning of beam delivery mechanism 26 of Processing device 4:

If bruting process is selected on monitor 24 through software installed in computer 21 ,laser beam falls on sliding beam bender 56. Then laser beam falls on lower beam bender 57 from which it travels towards lower focusing device 58 and hence focused laser beam falls on side of a rough stone 5 accommodated on diamond holder 8.

If Girdle polishing process is selected on monitor 24 through software installed in computer 21 then laser beam falls on upper beam bender 59 bypassing sliding beam bender 56. Now laser beam passes through upper focusing device 60 and hence focused laser beam falls on rough stone 5 accommodated on diamond holder 8.

Also upper focusing device **60** and lower focusing device **58** have illuminating component to illuminate rough diamond **5** by means of plurality of surrounding LED's for watching bruting process or girdle polishing process on CCTV **32**.

Functioning of CNC interface of processing device 4:

Motorized Rotatable Platform 23:

Surrounding excess surface of rough diamond **5** is removed by laser beam due to rotation of motorized rotatable Platform **23** on which diamond holder **8** is mounted horizontally. To drive the motorized rotatable platform **23**, stepper motor is used.

Motorized Y-axis positioner 30 and Motorized X-axis positioner 31:

During Bruting process, laser beam dipping into rough diamond **5** gradually until the maximum diameter **61** or cylindrical shape of the diamond achieved for which displacement of rough diamond **5** through motorized rotatable platform **23** on Y- axis and/or X-axis is required which is accomplished by motorized Y-axis positioner **30** and/or motorized X-axis positioner **31**. Motorized Y-axis positioner **30** is mounted on Motorized X-axis positioner **31** in such a way that Motorized Y-axis positioner **30** can travel on Motorized X-axis positioner **31**. Displacement of motorized X-axis positioner **31** and/or motorized Y-axis positioner **30** is done automatically or by manual data feed through software installed in computer **21**.

Movement of Motorized Y-axis positioner **30**, Motorized X-axis positioner **31** and rotation of motorized rotatable platform **23** are controlled by control card installed in computer **21**.

As Y-drive card **33** is connected to computer **21** & motorized Y-axis positioner **30**, it amplifies the electronic signal coming from computer **21** and send amplified signal to motorized Y-axis positioner **30**. Similarly X-drive card **34** and R-drive card **35** send amplified electronic signals to Motorized X-axis positioner **31** and Motorized Rotatable platform **23** respectively. Y-drive card **33**, X-drive card **34** and R-drive card b can be switched on/off through drive card power supply **36** connected to them. Motorized Y- axis positioner **30** and Motorized X-axis positioner **31** are driven

by stepper motors. Also limit switches are provided to each end of Motorized Y axis positioner 30 , Motorized X axis positioner 31 & motorized rotatable platform 23 to sense the home & end position.

A rough diamond 5 to be processed for bruting or girdle polishing can be watched on CCTV 32 through video system of processing device 4 consist of upper CCD camera 52 and lower CCD camera 53.

As laser bruting being a non-contact process gives more speed, reduces weight loss significantly and keeps the shape of diamond uniform. In novel laser bruting machine the computer becomes an important element in cutting of diamond. With the standard software computer suggest an optimal cut to have accurate rounded shape of the diamond taking dimensions & shape into account. Also the rough diamond stone to be centered and bruted is lit up by illuminating sources and these illuminating sources consist of plurality of LED's so the eye gets the impression that is always the same side of the stone that is lit and hence the illuminated rough diamond can be watched on CCTV through video system consist of CCD cameras. This is a useful technique, because novel bruting machine can check the process at all times without stopping the machine and the same can be operated by a single person. Summing up all the advantages productivity increases significantly by using novel laser bruting machine.